Los Alamos National Laboratory
Spallation Neutron Source

Linac BPM Systems
Preliminary Design Review

LANL Design Team Responses to the Review Committee Report

Work Package Manager: M. A. Plum 9/April/01
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Physics Review : James Stovall 3Dec01
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Division Director: D. J. Rej 12/5/01
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Work Package Manager:
The Work Package Manager is responsible for generating constructive and specific responses to the review committee's recommendations. Responses should be generated in a timely manner. Responses should incorporate the action to be taken, who is responsible for the action, the time frame by which the action will be completed if required before the Final Design Review, and any impact to the project cost, schedule or scope. Work Package Manager signature means that all responses having no significant impact on project cost, schedule, or scope will be incorporated into the design of the system. Responses that involve a significant impact to project cost, schedule, and scope must include a description of the impact and be approved prior to implementation by the Project Office.

SNS-2 Group Leader:
Reviews responses for overall technical merit, cost effectiveness and reasonableness for implementation. Reviews responses relative to interfaces with other accelerator systems and for potential impact to these systems.

SNS-3 Group Leader:
Reviews responses for overall technical merit, cost effectiveness and reasonableness for implementation. Reviews responses relative to interfaces with other accelerator systems and for potential impact to these systems.

Physics Review:
Reviews responses for impact to physics design.

Project Office Review:
Review responses for impact to project cost, schedule and scope. Approves or disapproves responses which impact project cost, schedule or scope prior to their implementation.

Division Director:
Provide final review and approval of responses prior to distribution.

Responses to the Design Review will be distributed to:

Work Package Manager
M. Lynch
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Responses prepared by J. O'Hara, M. Plum, and J. Power

The SNS Linac BPM System Preliminary Design Review was held at LANL on February 27, 2001. We received the review committee's report on March 6, 2001. We thank the review committee for their insightful observations and suggestions, and their timely response. In this document we shall address each observation and suggestion. Each item that requires action on our part will be tracked and the progress will be reported at the final design review.

Technical Review Observations and Suggestions
BPM Pickups

Committee Observation - Much **progress** is **apparent in BPM mechanical design** since the December meeting, especially for the DTL BPMs.

Response: *Observation noted.*

Committee Observation - **MEBT BPMs** are nearly **completed**; the design appears to be satisfactory.

Response: *Observation noted.*

Committee Observation - **HEBT BPMs** are only in **preliminary design** stage, but sketches appear to describe satisfactory designs and requirements seem straightforward. We would expect no problems for these designs provided normal precautions are taken to achieve vacuum and electrical connection integrity.

Response: *Observation noted.*

Committee Observation - **CCL and SCL BPM** design appears to be **progressing satisfactorily**. They are based on proven design techniques used at BNL. If there may be a weak link in the design, it is the pressure contact in the signal feedthrough path; BNL has reported no problems with this feature of the design.

Response: *The decision to utilize this type of electrical contact was made early on in the design process, based on the BNL experience. We expect to gain experience with this aspect of the design through prototyping and testing.*

Suggestion - Write **quality control procedures** to assure electrical integrity of the pressure contact in the signal path. Such a procedure might include an electrical resistance measurement at a moderate current level (not just a DVM measurement, you're looking for milliohms!) and a TDR or swept frequency network analyzer measurement.

Response: *A quality control procedure will be developed to include the suggested tests and any others deemed necessary.*

Committee Observation - It was noted during the review that the **SCL BPMs** may undergo a **vigorous "scrubbing"** at Jefferson Lab before connection to the cryo module assemblies.

Response: *Part of the cleaning process does involve soaking and scrubbing in an alkaline solution (micro-clean).*

Suggestion - Establish communications soon with the Jefferson Lab collaborators to **identify** and document any **special requirements** of the **SCL BPMs**. These may include materials issues, bake-out requirements, cleaning operations, or assembly and operational procedures in the superconducting linac section.

Response: *Communication has been established, Jefferson Lab has provided a cleaning procedure, assembly procedure, and bake out procedure for items to be used in the warm beam pipe. The cleaning procedure, though thorough, does not appear to be excessive. The bake-out procedure is conducted for 24 hours at > 200 C. The previously discussed quality control procedure will incorporate post-cleaning testing to verify the BPM's performance.*

Committee Observation - DTL BPMs suffer the most mechanical constraints and demanding requirements. **Excellent progress** has been made since December and it appears that a **satisfactory design** has been achieved provided Kaman delivers parts as specified. The committee's concerns now center around **schedule** and **quality assurance** to guarantee delivery of BPMs that realize the performance promised by the design. Lifetime vacuum and electrical connection integrity are at risk.

Response: *Observation noted.*

Suggestion - Keep on top of **Kaman's progress** with the feedthroughs.

Response: *Contact with Kaman has been ongoing. The current status of our initial order is Kaman is awaiting piece parts from a supplier that are due 3/16/2001. If those parts arrive on time our scheduled delivery is 3/28/2001.*

Suggestion Establish **fall-back plans** in case vacuum leaks develop in the feedthroughs either initially or after installation of BPMs in drift tubes.

Response: *The current fall-back plan is to remove the damaged drift tube assembly and cut out the leaking BPM and either replace it with a spare BPM or simply install a straight piece of tubing without the instrument. The drift tube is then replaced in the tank.*

Committee Observation - DTL BPMs must go through numerous **brazing and welding steps** during fabrication and assembly into drift tube.

Response: *Observation noted.*

Suggestion - Establish a **written vacuum integrity quality assurance plan** to be followed during BPM fabrication. This could be as straightforward as a list of tests to be performed and qualifications to be met at appropriate stages of fabrication. It should include vacuum leak tests to assure that cable connection to the right angle feedthrough does not ruin the vacuum integrity of the feedthrough.

Response: *Specifications for cleaning, handling, shipping, inspecting, and leak checking have been incorporated into the Statements of Work for the machining, brazing, and welding operations the BPM's will go through.*

Committee Observation - DTL BPM feedthroughs and cables are **captured and inaccessible** for repair after drift tube assembly. It is crucial to assure **electrical integrity** during drift tube assembly, storage, installation into DTL tank, and for long term operation. There will be stages in the life of these BPMs that the electrical cables and connections will not be in the loving care of the diagnostics engineer. Design features and quality tests must be in place to guarantee electrical integrity.

Response: *Observation noted.*

Suggestion - Incorporate **design features** to minimize vibration of the buried SMA connections and protect exposed cables and connectors during handling, storage, and operation.

Response: *Current plans include providing strain relief for the cables as they exit the drift tube stem. Connections inside the drift tube will be made using some type of thread locking system (yet to be identified) to maintain electrical contact between the cable and feed through.*

Suggestion - Establish **written electrical integrity quality assurance plan** for DTL BPM cabling and feedthrough components. This plan should include electrical tests, inspections to be performed, and qualifications to be met at appropriate stages of fabrication and assembly. Cable assembly tests, before installation, might include electrical resistance measurements of center conductor and shield under vibration conditions at a moderate current levels (you're looking for milliohms!), a 'hipot' up to the voltage rating of the cable to assure no soft shorts at connectors, and a TDR or swept frequency network analyzer measurement. A sensitive cable resistance measurement setup is easily constructed that will permit monitoring cable voltage drop on an oscilloscope while cable is wiggled and vibrated. Sufficient test current turns milliohms into millivolts without an amplifier. Similar resistance measurements and TDR/swept frequency tests should be performed just before drift tube is welded closed and again just before drift tube installation into DTL tank.

Response: *An electrical integrity quality assurance plan will be written*

Suggestion - In general, for all BPM pickups and before fabrication begins, prepare a set of **QC** steps to be taken throughout the fabrication process to assure required properties

including vacuum integrity, electrical integrity, cleanliness, ability to withstand bake-out, etc. as appropriate for each fabrication.

***Response**: Since the fabrication of the BPMs will be done by vendors, the statements of work will detail the quality assurance steps required for dimensional inspection, cleanliness, handling, and vacuum integrity. LANL personnel will be conducting the electrical integrity testing according to the plan to be developed (discussed above).*

BPM Electrical Performance and Electronics

Committee Observation - The expected **BPM pick-up electrical response** appears to be well understood and acceptable for anticipated system requirements.

Committee Observation - Given the incomplete state of requirements and system integration issues, a direction for **BPM electronics design** seems to be well along. The scope of the task, potential problems, and planned solution for individual signal channels appears to be well in hand. The committee believes the plan described is **feasible** to meet known requirements.

Committee Observation - System **requirements not yet defined** include interface to low level RF system, scope of required absolute vs. relative beam phase measurements (exactly which BPM locations will be involved), and cable plant flexibility. These impact signal handling at the very front end of the BPM/Phase electronics, cable phase matching requirements, potential electrical interference, temperature effects, and hardware layout options affecting phase measurement accuracy.

Suggestion - Strive to **reach resolution** on these and other outstanding requirements issues as early as possible.

***Response:** We agree, and will work towards resolving these uncertainties.*

Committee Observation - Requirement for and range of **adjustable gain** stage(s) required in BPM/Phase measurement front-ends seems as yet unresolved. Does one requirement apply to all BPM locations?

Suggestion - Proceed to **resolve** this uncertainty.

***Response:** A single programmable gain adjustment with a 1x/4x range is proposed. Variation of the fixed gain is easily done on the existing design by changing component values. These adjustments should be sufficient to cover the various dynamic range requirements.*

Committee Observation - **Phase measurement accuracy and resolution** depend on the stability of the 2.5Mhz reference signal and on higher frequency signals derived from that.

Suggestion - Establish quantitative **specifications** for amplitude stability and phase noise characteristics of the 2.5Mhz signal received by the BPM/Phase electronics.

Response: *We agree, and will establish these specifications.*

Committee Observation - BPM/Phase measurement design depends critically on the analog **front-end boards** to be supplied by BERGOZ.

Suggestion - Plan a thorough **qualification testing program** for the first boards to be received and begin testing as soon as possible. Testing should be performed with test signals of the same spectral energy density as anticipated beam signals and over the full signal level dynamic range. Mate to digitizer and PCI board as soon as possible so as to do testing in final system environment.

Response: *We agree, and will strive to perform all the characterizations that relate to performance requirements. Duplicating the spectral energy density is difficult, but we will do as best we can with at least the fundamental and the two closest harmonics.*

Committee Observation - BPM/Phase measurement accuracy and resolution depends critically on the performance of the **built-in calibration system.** There are many potential problems. Analog RF switches on front-end electronics are a critical part of calibration system. The calibration system described depends on a minimum cable length between electronics and pick-up, yet MEBT apparently does not satisfy this minimum length. Cable plant specifications have yet to be determined as civil construction plans become finalized.

Suggestion - Proceed at full speed with **quantitative testing of calibration scheme** as soon as electronics assemblies become available.

Suggestion - Don't base design of **critical element** of BPM/Phase measurement system on unknown, perhaps uncontrollable, parameters.

Suggestion - Electronics **packaging issues** should begin to be addressed with the goal of a design that will facilitate performance, trouble-shooting, maintenance, and replacement. Available rack space and cable entry options should be considered in packaging design.

Response: *We agree, and will begin testing the proposed calibration technique as thoroughly as possible as soon as we get hardware. This will likely be an ongoing effort for some time. We have started to look at the packaging issues in detail within the last week. We recognize that the calibration system performance will establish the accuracy and usability of the BPM systems, and we will strive to eliminate all applicable uncertainties.*

BPM Data Acquisition

Committee Observation - It appears that there is already a **commitment** to a PCI based data acquisition path and that considerable work has been completed to assure the feasibility of this design. The committee agrees that the plan seems acceptable and sounds promising.

Suggestion - At this point, we can only recommend getting a complete **prototype acquisition system up and running** coupled with a real analog front end as soon as possible. This will allow maximum time to resolve any problems that may be encountered. Good Luck.

Response: *We agree, and are proceeding as quickly as we can with our available manpower.*

Committee Observation - The issue of **software version and repository control** for all levels of firmware and software was raised.

Suggestion - In this regard the committee can make no specific recommendation; only to urge the management to recognize the need and support efforts to establish a satisfactory method of control.

Response: *We did not present much on this issue at the PDR, but we have been considering a number of options. We are somewhat limited to define this better until the low-level interface and driver software has been written and tested. We are fully cognizant of the necessity of revision control of all software used.*

Appendix

Review Committee
Robert Webber, FNAL, Chairman
Jim Crisp, FNAL
Ron Johnson, SLAC

Speakers at the review
Jim O'Hara
Mike Plum
John Power
Matt Stettler

Non-LANL guests
Saeed Assadi, ORNL
Craig Dawson, BNL
Dave Purcell, ORNL
Ken Reece, ORNL
Tom Shea, ORNL

Labs attending via video conference
BNL
LBL